

BOTANY.—*Atropellis species from pine cankers in the United States.*¹

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INTRODUCTION

In various areas of the United States certain dermateaceous or tryblidiaceous fungi occur in association with twig or stem cankers of one or more species of *Pinus*, most frequently of species of hard or pitch pines (subgenus *Diploxyton* Koehne). These diseases, recently summarized by Boyce (1), have attracted the attention of pathologists only during the past 25 years.

The first was reported in 1921 by Weir (11), who described *Cenangium piniphilum* as a new species associated with stem cankers of *Pinus contorta* Loud. and *P. ponderosa* Lawson in Idaho and Montana. At that time Overholts (8) had observed cankered twigs of *P. rigida* Mill. in Pennsylvania, and later in the same State similar cankering of *P. pungens* Lamb., and considered the fungus associated to be a species of *Crumenula*, one possibly identical with *C. pinicola* (Rebent.) Karst., which has been reported (5, 7) as pathogenic to pines in Europe. Subsequently, Zeller and Goodding (13) described *Atropellis pinicola* as a new species in association with branch and stem cankers of several species of pine in the Pacific Northwest. They allied the fungus with *Scleroderris treleasei* Sacc. of Alaska in a new genus, *Atropellis*.

In 1932 specimens of *Atropellis* canker collected on *Pinus sylvestris* L. near Portsmouth, Ohio, and near Mount Alto, Pa., were received by the Division of Forest Pathology, U. S. Bureau of Plant Industry.² The following year an investigation of the disease was undertaken by the Civilian Conservation Corps, in cooperation with the Forest Service and the Division of Forest Pathology, and from the field surveys made approximately 500 collections of canker fungi accrued. The writers have had the opportunity to classify these specimens, which are largely from the Eastern and Southeastern States (2, 3). The present paper is concerned with the taxonomy of specimens representative of the various susceptible hosts in these areas, studied in comparison with authentic specimens of the canker fungi in the Western States.

¹ Received December 13, 1939.

² Collections by Dr. Curtis May and Dr. L. W. R. Jackson, respectively; also reported to the Division of Forest Pathology by Prof. J. S. Boyce as occurring on *P. sylvestris* and *P. resinosa* Soland. in Massachusetts and New Hampshire.

TAXONOMY OF SPECIES ON PINES

With respect to the previously mentioned so-called *Cenangium*, *Crumenula*, and *Atropellis* cankers in the United States, which are characterized by a grayish-green to blue-black coloration of the wood (Fig. 1, c) beneath each lesion (1), the causative fungi seem to be sufficiently closely related to be properly considered within a single genus. In some features, particularly the roughened exciple and the elongate, septate spores, the species here referred to *Atropellis* resemble those of *Crumenula* described as occurring on pines in Europe. The latter, however, are characterized by Rehm (9) and Lagerberg (7) as having the apothecium with circular opening, entire margin, pale hymenium, and long, fine excipular hairs. The American fungi differ from *Crumenula* in the furfuraceous exciple, stellate or irregularly lacerate aperture, and blue-black epithecium, as well as in the type of canker produced and the characteristic discoloration of the host tissue by the mycelium. In their clavate to elongate-fusoid ascospores the species are suggestive of *Scleroderris* as used by Karsten (6) and Rehm (9) but are dissimilar with respect to paraphyses, aperture, and exciple. It has been suggested that a possible relationship exists between these species and *S. bacillifera* (Karst.) Sacc., as mentioned by Zeller and Goodding (13). This fungus, however, as represented by Karsten's *Tympanis bacillifera* (Fung. Fenn. 756, Cent. 8, 1868, in the Farlow Herbarium, Harvard University) on bark of *Picea* ("granbark") has smooth, patellate apothecia, which conform in gross and microscopic features to the description by Karsten (6, cfr. Saccardo, Sylloge Fung. 8: 595) and, except for arrangement of spores to that by Rehm (9). In the writers' preparation of F. Fenn. 756 ascospores are 0- to 5-septate, 22-36 by 3-3.5 μ , subspirally overlapping, with three or four in the apex of the ascus.

It seems advisable, therefore, to recognize *Atropellis* as a distinct genus for the species associated with pine cankers in the United States, with certain revisions of the genus and species as described by Zeller and Goodding (13, p. 561) for pines.

Atropellis Zeller and Goodding, emend.

Apothecia erumpent, externally furfuraceous and brownish to black, fleshy coriaceous, single or cespitose, sessile to substipitate, cupulate to patellate, laciniately dehiscent, hymenium concolorous, bluish black or lighter; asci clavate, 8-spored; spores fusoid to narrow cylindrical-clavate, hyaline, continuous, then 1- to 3- (rarely 5-) septate; paraphyses hyaline, septate, simple or branched, exceeding the asci, end cells equal or slightly swollen, forming a colored epithecium, agglutinated below and granular

encrusted above by yellowish-brown, pinkish, or violaceous excretion; hypothecium typically thick, subtended by a hyaline medullary tissue; ectal layer dense, dark, furfuraceous.

Conidial stromata, where known, of similar habit, texture, and color; fertile cavities variable, usually coalescing, the pustules dehiscent by one or more papillulae; conidiophores simple or subverticillately branched; conidia minute, acrogenous, bacillar, continuous, hyaline.

In each of the following species the pinkish or violaceous material in and above the hymenial tissue of both conidial and apothecial fructifications is readily dissolved by sodium or potassium hydroxide solutions, which are immediately colored greenish or bluish. If a hydroxide solution is used as a swelling agent in microscopic preparations, the cytoplasm of young asci and ascospores appears greenish rather than hyaline. Overholts (8) describes this reaction in his account of the fungus associated with the canker of *Pinus pungens*, presumably the second of the following species.

***Atropellis pinicola* Zeller and Goodding** Fig. 2, A-B

Zeller and Goodding (13) record *A. pinicola* on *Pinus contorta* Loud. and *P. lambertiana* Dougl. in Oregon, and on *P. monticola* D. Don. in Oregon, Washington, Idaho, and British Columbia. Zeller (12) also reports the species on *P. lambertiana* in California and on *P. strobus* L. in Oregon.

Atropellis pinicola differs from the three following species primarily in its longer and narrower spores, which Zeller and Goodding, upon the examination of numerous specimens, record as "32-63 \times 1.5-3.5 μ (average 40 \times 2 μ)," and in its more frequent occurrence on soft pines. Specimens examined by the writers have spores typical in size and shape, although not uniformly 1-celled as originally described, but frequently 2- to 4-celled, and occasionally 6-celled.³ The paraphyses are septate, simple or forked, with the tip cells equal, or swollen and up to 4 μ in diameter. The conidial fructifications and conidia observed conform to the descriptions under the succeeding species. (Cf. 12, p. 464.)

***Atropellis tingens* sp. nov.** Fig. 1, B, C, F-H; Fig. 2, C-L

Apotheciis sessilibus vel substipitatus, ex cortice erumpentibus, subglobosis dein patelliformibus, coriaceis, 2-3 mm diam., furfuraceis, atris, margine laciniato, hymenio atro-coeruleo; ascis clavatis, longe pedicellatis, octosporis, (70) 90-110 (150) \times 8-10 (14) μ ; ascosporis 2-3-seriatis, anguste fusiformibus, rectis, curvatis vel sigmoideis, (20) 24-40 (46) \times (2) 2.5-3.5 (4) μ ; paraphysibus simplicibus ramosisve, apice incrustatis, epithecium atro-coeruleum formantibus; hypothecio brunneo, strato interiore hyalino, cortice denso, atro, rugoso; fructibus conidicis pustulatis, atris, furfuraceis, plicatis; conidiophoris ramosis, 35 \times 1.5 μ ; conidiis bacillaribus, continuis, hyalinis, 4-8 \times 0.5-0.7 μ . Hab. in cortice ramorum vivorum Pini.

Apothecia sessile to substipitate, single or gregarious, erumpent through the bark of cankered areas, often concentrically arranged, subglobose when young, expanded to cup-shaped or patellate, contorted or compressed when crowded, opening by irregular splitting, coriaceous, 2-3 mm diam., exterior black, furfuraceous, margin lacinate, incurved, when dry often hysteroid

³ Specimens examined: Oregon Agr. Coll. Herbarium no. 4877 (courtesy of S. M. Zeller); nos. 1304, 1635 (ex type), 1679, 1968, and 1969 in the herbarium of J. S. Boyce, Yale University; Forest Pathology nos. 86401-86405; Mycological Collections, U. S. Bureau of Plant Industry, nos. 66565-66567, 71100-71104.

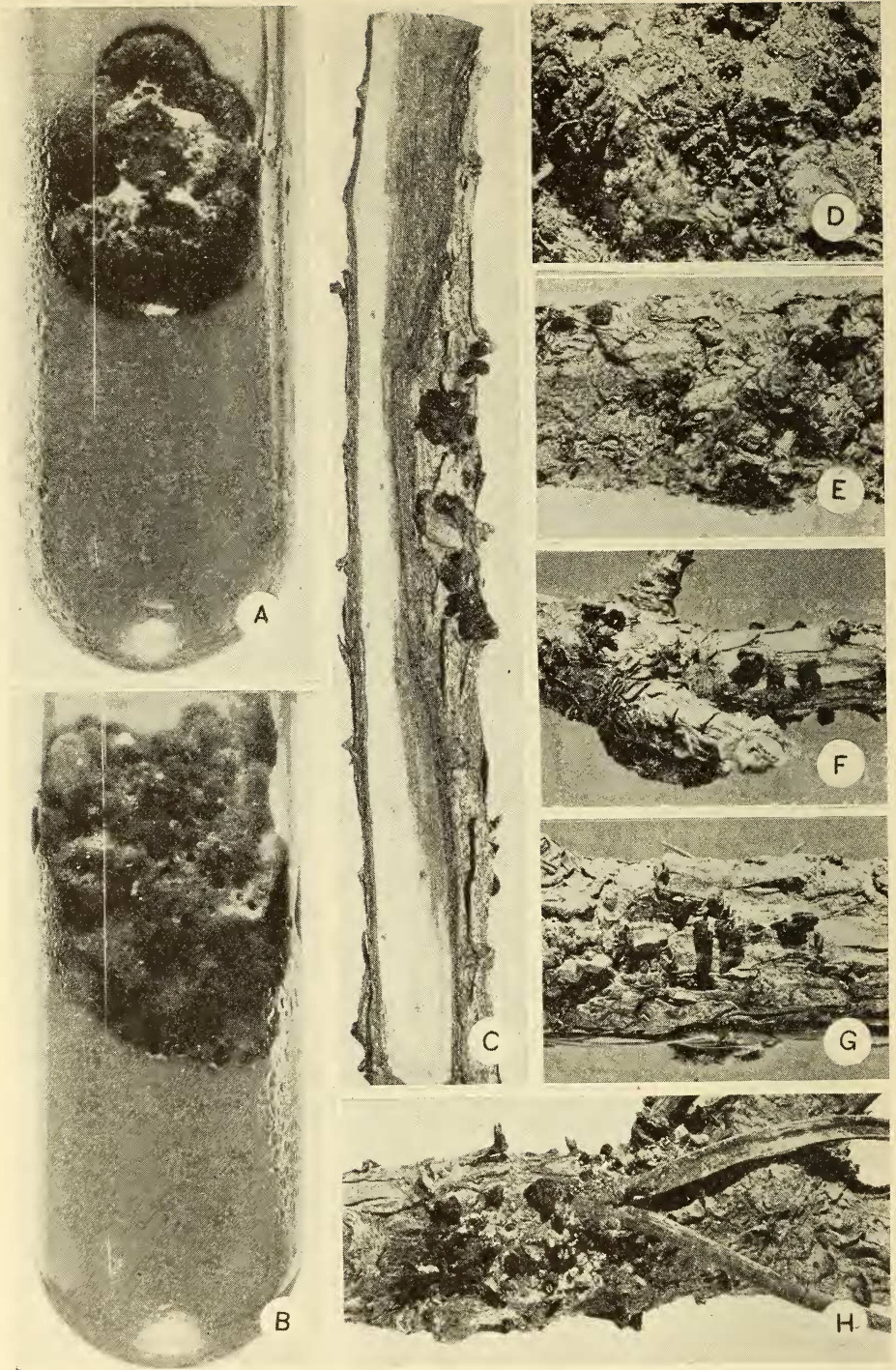


Fig. 1.—(See opposite page for explanation)

in form, hymenium blue-black, pruinose. Asci clavate, long-pedicellate, apex rounded, 8-spored, (70) 90–110 (150) \times 8–10 (14) μ ; spores irregularly 2–3 seriate in the upper part of the ascus, slender fusiform, broadest near the apex and tapering below, straight, curved or sigmoid, hyaline, continuous then 1–3 (rarely 4–5) septate, (20) 24–40 (46) \times (2) 2.5–3.5 (4.0) μ ; paraphyses sometimes simple, more frequently branched and slightly thickened at the tips, septate, subhyaline, granular-encrusted, forming a dense purplish- or bluish-black epithecium. Hypothecial layer 20–25 μ thick, brown; underlying tissue of fine, loosely interwoven, hyaline or subhyaline hyphae, forming a layer 70–110 μ thick; cortex 30–100 μ thick, very dense, black, roughened on the outer surface by clumps of thick-walled, brown, closely septate hyphae. Conidial fructifications pustulate, erumpent, black, furfuraceous as in the apothecia, irregularly chambered or folded, the folds lined with branched conidiophores 35 \times 1.5 μ ; conidia borne at the tips of the branches, bacillar, continuous, hyaline, 4–8 \times 0.5–0.7 μ .

On cankered twigs, branches and small stems of *Pinus banksiana* Lamb., *P. caribaea* Morelet, *P. clausa* (Engelm.) Sarg., *P. densiflora* Sieb. & Zucc., *P. echinata* Mill., *P. nigra* Arn., *P. pinaster* Ait., *P. pungens* Lamb., *P. resinosa* Soland., *P. rigida* Mill., *P. rigida* var. *serotina* (Michx.) Loud., *P. strobus* L. (infrequent), *P. taeda* L. and *P. virginiana* Mill., from New Hampshire to Florida, west to Ohio and Arkansas (2, 3). Type specimen: *Diller* 24 on *Pinus rigida*, Camp Roosevelt, George Washington National Forest, Va., June 12, 1933.⁴ All of the specimens on *Pinus strobus* were obtained near Mount Solon, Va.

The ascospores of this species are regularly shorter and broader than those of *Atropellis pinicola*, averaging approximately 30 \times 3 μ , but of the same degree of variation. With respect to a single apothecium, spores in general are less variable in width than in length. When relatively broad ascospores are encountered, they are of the shape characteristic of the species and average considerably longer than those of the next succeeding species.

The specimens examined show that apothecia with mature spores may be found throughout the year, as Zeller and Goodding note for *Atropellis pinicola*. Yet much sterile material is encountered among samples from the surveys and among the writers' casual collections made during all seasons of the year. Possible perennial sporulation on living or weakening twigs and stems is suggested by the arrangement of the apothecia and degrees of development on cankers of long standing.

While this species is suggestive of *Atropellis pinicola* in the shape and arrangement of the ascospores and of the following species in its general occurrence on hard, rather than soft, pines, it is clearly intermediate to the two with regard to spore size.

⁴ The type and other representative specimens are deposited in the Mycological Collections, U.S. Bureau of Plant Industry; portions of the type and several other collections are also in the Farlow Herbarium of Harvard University and the herbaria of the New York Botanical Garden and the University of Michigan.

Fig. 1.—A–B, Seven-weeks-old cultures of *Atropellis* on malt agar medium, kept at room temperature: A, *Atropellis arizonica* from *Pinus ponderosa*; B, *A. tingens* reisolated 21 months after *Pinus echinata* was inoculated with a culture from *P. caribaea*. C–H, *Atropellis* on various pines: C, *A. tingens* on *P. pungens*, North Carolina; D, *A. piniphila* on *P. ponderosa*, Idaho; E, *A. arizonica* on *P. ponderosa*, Arizona; F, *A. tingens* on *P. sylvestris*, Ohio; G, *A. tingens* on *P. taeda*, Virginia; H, *A. tingens* on *P. pinaster*, North Carolina. Figures A–H, $\times 2$; all photographic negatives by M. L. F. Foubert.

The species grows very slowly in cultures held at room temperature, producing uneven, elevated, black, compacted or loosely stromatic surface mats of irregular outline and with scattered and marginal, fine grayish to violaceous tomentum on potato-dextrose and malt agar media, and less erumpent colonies with black subsurface mycelioid margins on corn meal agar. Identical colonies were obtained from plantings of infected wood of various species of pines. The conidial stage developed in irregular, convoluted areas, was observed in isolations from *Pinus banksiana* Lamb., *P. caribaea* Morelet, *P. echinata* Mill., *P. pinaster* Ait., and *P. pungens* Lamb.,

***Atropellis piniphila* (Weir) comb. nov.** Fig. 1, D; Fig. 2, M

As mentioned above Weir (11) reports this fungus as *Cenangium piniphilum* on *Pinus contorta* and *P. ponderosa* in Montana and Idaho. More

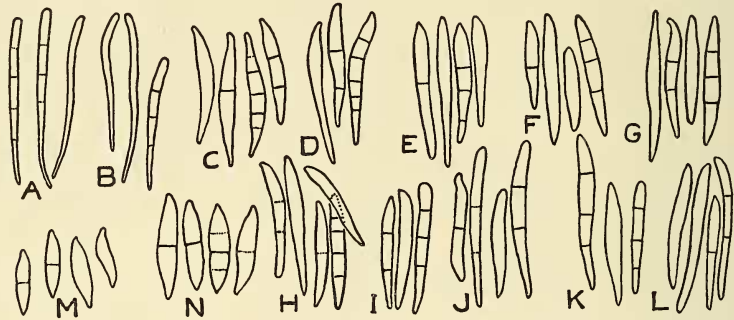


Fig. 2.—Ascospores of four species of *Atropellis*; $\times 500$. A, *A. pinicola* on *Pinus monticola*, Oregon; B, same on *P. contorta*, Oregon; C–L, *A. tingens* on various pines in the Eastern States (*Pinus virginiana*, *taeda*, *pungens*, *caribaea*, *sylvestris*, *banksiana*, *echinata*, *rigida*, *resinosa*, and *strobus*, respectively); M, *A. piniphila* on *Pinus contorta* (type specimen); N, *A. arizonica* on *Pinus ponderosa*.

recent accounts (1, 12) indicate its further occurrence in the Pacific Coast States on these hosts and on *P. albicaulis* Engelm., and (4) in Arizona and New Mexico on *P. ponderosa*. Specimens examined in the present study add other hosts and extend the range of the species to New Mexico and stations in the Southeast.⁵ The species occurs on both soft and hard pines but infrequently on the former.

The apothecia are as characterized for the genus, with the hymenium brownish to black, averaging somewhat larger than those of the two preceding species. The asci are longer and broader, measuring (100) 120–135 (170) \times 10–15 μ , and the tendency for the spores to be clumped in the upper end also obtains in this species, with the upper two to six spores biserially overlapping. Paraphyses are septate, simple or branched, with the tip cells

⁵ Specimens examined: Weir 2631 (locality unknown: probably Dakotas), on *Pinus banksiana* Lamb.; Weir 2624 and 2625 (Idaho), 2626 (Montana), 2627 (Washington), and *Forest Pathology* 14973 (type) and 15532 (Idaho), all on *P. contorta* Loud; Weir 2633 (Oregon), *P. jeffreyi* "Oreg. Com."; Weir 2628 (Idaho), *F. P.* 89367 Gill & Ellis (New Mexico), *P. ponderosa* Lawson; Weir 2630 (Alabama), *P. taeda* L.—all in Mycological Collections, U.S. Bureau of Plant Industry; Boyce 766 (ex-type), and 1659 (Idaho), *P. monticola* D. Don.—Herbarium of J. S. Boyce; Diller 311 (Tennessee), *P. virginiana* Mill.—courtesy of J. D. Diller.

equal or swollen. The hymenium in section shows the purplish tints characteristic of species of this group. Ascospores are elliptical-fusoid, with ends rather acute, straight or subsigmoid, and measure (14) 16–22 (24) \times (3.5) 4–5 (5.5) μ , averaging $18 \times 5 \mu$ in the type specimen. While Weir describes and illustrates the spores as 1-celled, 1- and 2-celled spores occur in half of the specimens listed herein, including the type. The conidial stage observed in association with apothecia (Boyce number 1659) is morphologically identical with that of *A. tingens*.

Sydow and Petrak (10) determine this fungus as *Cenangium farinaceum* (Pers.) Rehm, which occurs on branches of *Pinus sylvestris* in Europe, making particular note of the coloration in the hymenium ("Paraphysen") and epithecium. Rehm (9) notes that in this respect *C. farinaceum* differs from other species of *Cenangium*. The accounts, however, do not indicate that the European fungus is pathogenic or that it discolors the wood. On the basis of Rehm's description *C. farinaceum* has smaller asci and shorter and broader, 1-celled spores, which have obtuse rather than acute ends. Whatever the relationship between these fungi may be, the American specimens can not be identified as *Peziza pinicola beta caespitosa* of Fries (Syst. Myc. 2: 113; *Peziza farinacea* Pers., Syn. Fung., p. 672), which in the specimen distributed by Fries ("294. *Peziza farinacea* b. Syst. Myc." in the Farlow Herbarium, Harvard University), shows numerous flattened, smooth, black and shining apothecia up to 0.6 mm broad when dry, occurring singly or clustered on a large sheet of bark sufficient to indicate that fruiting was not associated with a canker condition. Therefore, the synonymy that Sydow and Petrak suggest is considered untenable.

Atropellis arizonica sp. nov. Fig. 1, A, E; Fig. 2, N

Apotheciis substipitatus, ex cortice erumpentibus, subglobose dein expansis, coriaceis, atris, 1.2–2.5 mm diam., furfuraceis, margine undulato, lacinato, incurvato, hymenio pruinoso, atro-coeruleo; ascis cylindrico-clavatis, apice obtusis (90) 100–120 \times 9–14 μ ; ascosporis 2-3-seriatis, elliptico-fusoidis, rectis vel subsigmoideis, continuis vel 1-3-septatis, (20) 24–28 (32) \times (4) 4.5–6 (7) μ ; paraphysibus filamentosis, septatis, ramosis; hypothecio brunneo; strato interiore hyalino, cortice crasso, atro, rugoso; fructibus conidicis pustulatis, nigris; conidiophoris ramosis, 12–20 \times 2 μ ; conidiis bacillaribus, hyalinis, continuis, 4–6 \times 1–1.5 μ . Hab. in cortice ramorum vivorum Pini.

Apothecia substipitate, erumpent singly or in groups of two to three, scattered over bark of cankered areas of the host, subglobose when young, then expanded and patellate, sometimes irregularly contorted and compressed when crowded, leathery, black, 1.2–2.5 mm diam., exterior furfuraceous, margin undulate, lacinate, incurved when dry, hymenium pruinose, blue-black. Asci cylindrical-clavate, obtuse at the apex, gradually attenuated toward the base, 8-spored, (90) 100–120 \times 9–14 μ ; spores irregularly 2-3-seriate in the upper part of the ascus, 1-2-seriate below, elliptic-fusoid, straight or subsigmoid, tapering at both ends, continuous to 1-3-septate, equal or slightly constricted at the central septum, (20) 24–28 (32) \times (4) 4.5–6 (7) μ ; paraphyses filamentous, septate, branched above, the tip cells equal or swollen, dilute pinkish in mass, covered by a dense blue-black epithecium. Hypothecium brown, 45–65 μ thick; inner layer of tissue 100–150 μ thick, of loosely interwoven, subhyaline hyphae; cortex 100–250 μ thick, black, dense, exterior roughened and covered with loose clumps of

dark, closely septate hyphae. Conidial fruits pustulate, black, furfuraceous as in the apothecia; conidiophores simple or branched, pale violaceous in mass, $12-20 \times 2 \mu$; conidia bacillar, hyaline, continuous, $4-6 \times 1-1.5 \mu$.

On stems of *Pinus ponderosa* Lawson, Hospital Flat, Safford, Ariz., September 22, 1934, D. J. Stouffer.

This species is known only from the locality of the type specimen, which was obtained at an elevation of 9,000 feet. It is closely allied with *A. piniphila* but has longer and broader spores, in their form suggestive of certain species of *Crumenula* on pines in Europe. In cultural aspects the species resembles *A. tingens*. The conidial stage was obtained in cultures from isolated groups of ascospores discharged upon plates of nutrient agar.

SUMMARY

The genus *Atropellis* is revised to include along with *A. pinicola* Zeller and Goodding, of the Pacific Northwest, two new species, namely, *A. tingens* and *A. arizonica*, and *Cenangium piniphilum* Weir, all of which cause characteristic cankers of pines. Of these *A. tingens* is of widest occurrence, on various species of native and introduced pines in the eastern half of the United States, and *A. arizonica* is most limited in distribution, being known only from the type locality, Safford, Arizona. Each of the species produces a localized, dark stain of the wood in cankered twigs or stems.

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